Pål Spilling; short CV

Born: October 29th 1934, in Harstad, Norway.
Education: received his cand.real. degree in physics at University of Oslo in March 1963, and his Ph.D. in experimental nuclear physics from University of Utrecht, the Netherlands in July 1968.
Current position: Professor with the University of Oslo, assigned to UniK – University Graduate Center at Kjeller, Norway.
Teaching/research: He has regularly given graduate and undergraduate courses in
Computer Communication and security, from 1985 until today.
Current research: security and wireless communications.
Work experience: 1963 – 1971; nuclear physics research; universities of Utrech and Eindhoven
1972 – 1982; Norwegian Defense Research Establishment; Internet research
1982 – 1993; R & D Department of Telenor; Internet research and fiber comms.
1993 – 2005; UniK/Oslo University; professor Communication networks, security, mobile communications.

Additions to the interview given at Stanford July 28th, 2005

1. **A sentence or two that defines your work or thoughts**
   At the time ARPANET was conceived, computers were costly, programs were costly, and communication lines were costly. The main objective behind the development then, was to share expensive resources in a robust and efficient manner between geographically distributed users.
   A good example is the following: I was participating in speech experiments across the ARPANET around 1978, and had to modify a voice applications program for our PDP-11/40, located next door to my office at the Norwegian Defense Research Establishment (NDRE). All programming support was hosted at a computer at ISI just north of Los Angeles. The access to these resources went via my terminal connected to NORSAR-TIP and the Telnet program. I could then use a text editor for the modification of the existing program, and then assembling and linking the modified program, then using the XNET debugger to upload the program across the network and into the PDP-11/40, and then use the debugging facilities in the XNET to step through the program instruction for instruction, to observe that all was correct.

   Then came the internet, personal workstations, later Lap-Tops, and then the Web, and the network was transformed into sharing of a global information base

2. **Two anecdotic situations**

Landing in Los Angels in 1977 to attend an ARPA-meeting somewhere in California, and discovering that I had forgotten to bring with me the meeting information. Luckily I found my way to ISI where a friendly PhD-student let me in and gave me access to a terminal, so that I could read my mail and get the meeting information.
By the way, ISI was at that time hosting my email account.

Around November 1 1983 Ronald Mark Austin, a 19-years old student at UCLA, was arrested and charged with illegal access to and theft from a large number of computer systems connected to the ARPANET. Among those were several systems belonging to the American defense. It was also believed that Austin had broken into the main campus system at Kjeller Norway, which served both the Norwegian Defense Research Establishment (NDRE), The Norwegian Air Force base at Kjeller, and Oslo University, according to one of the Norwegian newspapers – blowing up the story in large headlines. It turned out to be my VAX-750 that was invaded, used for my collaboration with the DARPA community, and contained neither defense secrets nor other sensitive material. I had a hard time responding to all phone calls received from national security people, the research institutes at Kjeller, the Defense Security Agency, and lots of newspapers. In addition I received a subpoena from the Court in Los Angeles. When they learned about the real situation, the subpoena was of course cancelled.

3. **Do you remember when you had your first contact with a computer?**
   I had my first real contact with a computer in 1964, when I had to process data from nuclear physics experiments recorded on large rolls of paper tapes. At that time I was working on my PhD research performed at the Dutch nuclear reactor in Petten. The computer was also Dutch, and the program was written by software experts at the Dutch Reactor Centrum.

   Some years later I worked with the University of Technology in Eindhoven, also doing experimental research in nuclear physics. I had just received a FORTRAN program, on IBM punch-cards, to help me process and analyze my experimental results, but did not find the output too suitable for my purpose. I then proceeded to modify the output part, which was my first contact with FORTRAN programming. For an experienced programmer this was certainly a trivial task, but not for me. So I was very proud of myself when I had the modifications fixed and running as I wanted.

4. **What was your first contact/experience with the Internet or ARPANET?**
   Working with the Norwegian Defense Establishment (NDRE), I was asked in 1975 to participate in the newly established collaboration between NDRE and DARPA. I said yes, but did not realize fully what I was doing, considering my background in electronics and nuclear physics. My first task was to participate in a meeting in professor Cerf’s group at Stanford

University in 1975/76. With my background I did not get much out of the meeting, except that they were discussing details of the TCP protocol.

My first contact with the ARPANET was around the same time. NDRE had agreed to participate in the SATNET project, and in this connection I was put in charge of getting a Norwegian-built computer, located at NDRE, hooked up to the ARPA-node at Kjeller (NORSAR-TIP). Due to the distance to the TIP, we had to use the 1822 VDH interface. I got the interface specifications from BBN in Boston and had a technician at NDRE to build the hardware interface. To my disposition I had a naked computer without any form for operating system, and an assembler, a linker, and a loader program. It was obvious that I first had to develop a multitasking system for the computer and then the driver for the 1822 interface. I was very lucky to get hold of a SRI report by Dave Retz describing the ELF operation system for PDP-11/45. It gave me sufficient understanding of what a multitasking system should do, so that I could proceed to implement my own. After quite a bit of work and frustrations, I the computer hooked up to NORSAR-TIP – to great satisfaction for myself.

5. **In your opinion, what are the key characteristics of Internet and the most important milestones?**

Key characteristics:

- the internet technology can utilize any underlying network transport technology. This means that any network should be able to connect to any other network without requiring internal modifications
- the packet transport in the network is connectionless. It utilizes adaptive routing, hence the network will be very robust with respect to failures
- no central management and control
- the network is open, meaning that the host computers are always on, with the consequence that the hosts are prone to illegal access and hacking
- user security is not directly part of the network, but handled outside the network domain. But all security support functionality is directly accessible from the internet, hence vulnerable and prone to hacking

Important milestones:

- The implementation of the ARPANET and the host-to-host communications in the timeframe 1969 till 1972 (mail, FTP & Telnet)
- the TCP testing performed in October 1975 between Stanford University and University College London
- Two – network demonstration in 1976 at SRI, between a PRNET and ARPANET, and the multi-network demonstration performed in 1977 across SATNET-ARPANET, between Local Area Networks in USA, London, and Kjeller Norway.
- The ARPANET – Internet went through three distinct phases:
  - the basic research and development phase sponsored and supervised by DARPA; ARPANET – Internet was a closed group from it inception in 1968/69 until 1983 when all ARPANET host converted to the TCP/IP suite of protocols. All participating institutions had to be accepted by DARPA
  - an interim phase; the network was split in two parts. One part, called MILNET, contained all defense institutions. The other part, still called ARPANET, was open to research institutions in general, not only in the US but also in Europe. At the end of the decennium, NSF had taken over the responsibility for the main part of the US – network, and with interconnections to networks in Europe and other continents. Many of the regional networks were privatized.
  - the World Wide Web was invented at CERN in 1989, and the first commercial browser was available in 1993. At the same time the restriction on commercial use of the network was lifted, and was the start of the third phase. This resulted in an explosive growth of the internet.

6. **How did you contribute to the development of the internet?**

As mentioned previously, I implemented the first Norwegian host on ARPANET. Via my primitive host at NDRE, connected to the NORSAR-TIP, I could set up the satellite nodes (SIMPs) to generate artificial traffic in SATNET, and collect traffic measurement data and have those shipped to my host at NDRE for off-line processing. The objective of the SATNET project was to study access control algorithms, in order to devise one suitable for both normal datagram traffic and traffic with real-time properties (voice). ~~NDRE~~A colleague of mine and I participated extensively in these activities, both theoretically and experimentally.

Having a proper access control algorithm in place, SATNET was used as an autonomous network interconnecting local area networks, at NDRE and University College London, with ARPANET, and proved to be a very suitable arena for developing and refining the internet gateway technology. NDRE was mainly an observer to these activities.

At the end of the SATNET project, 1978-79, I participated in extensive packet speech experiments and demonstrations mainly involving Lincoln Lab, UCL, and NDRE. My task here was to study the traffic profile of packet speech traffic in the network. The programming to be done in this context was, as previously mentioned, a good example of resource sharing – the original paradigm the ARPANET built on.

After the SATNET project came to an end in 1979/80, it was put into experimental operations to interconnect local area networks (LANs) at NDRE and UCL with ARPANET. In 1982 I moved over to Telenor R&D, and continued the collaboration with the DARPA community from this location. Moving to Telenor R&D enabled me to create a small Norwegian internet, interconnecting LANs located at the universities in Oslo, Trondheim and Bergen, and at Telenor R&D, and from there on to SATNET and then on to the US.

7. **Name a few key people in the development of the internet, leaders and trendsetters?**
   The development of computer networks was in many ways inspired by JCR Licklider's vision presented in the seminal paper "Man – Computer Symbiosis" from March 1960. Independently of one another, Paul Baran, then at Rand Corporation, Len Kleinrock at UCLA, and Donald Davies at NPL in England, in the 1960s, studied different aspects of message/packet switching. In 1965 Larry Roberts, then at Lincoln Lab, was awarded funding from DARPA for an experimental project developing the functionality to exchange digital information over a dial-up phone line between a computer at Lincoln Lab and a computer at SDC in Santa Monica. Shortly after he had demonstrated this capability, in 1966, he was asked to join the IPTO office at DARRPA to lead the new project to develop a wide area digital communications network, that later was named ARPANET.

After having managed the project and seen a reasonable mature ARPANET in operation, interconnecting hosts distributed across the American continent, Larry Roberts left DARPA in 1973 to become President of Telenet, providing commercial data communication services based on the X.25 standard. This is kind of strange. The X.25 standard is based on connection-oriented transmission in the network, promoted very strongly by the standardizations community, while the emerging technology in the DARPA community and the soon-to-be foundation for the internet technology was based on the datagram paradigm. These two communities were strongly opposed to one another, like cats and dogs.
Does this mean the Larry Roberts at that time did not believe in the datagram concept?

Robert Kahn, with experience from BBN in designing and specifying the ARPPANET IMPs, joined the IPTO office in 1972, and later became its director. In 1973 he and Vint Cerf, then an assistant professor at Stanford, conceived the main principles the internet should build on, and that was published in May 1974. These two people were the driving force behind the internet development. But there are numerous other people that have contributed to the this development, all in a giant symphony conducted by Bob Kahn and Vint Cerf. May be I should mention one person that have had an enormous impact on the usability of the internet, namely Tim Berners-Lee and his invention of the Web.

8. **What do you think about the future of the internet?**
   The internet will increasingly encapsulate the whole world, gradually converting it into the so-called global village~~,~~. It will enable people from different cultures to access the same global information base and provide them with an easy way to communicate and exchange view, and thereby hopefully reduce the tensions between the people/cultures of the global village and enable peaceful coexistence.
   ~~But the~~
   The internet is penetrating into all aspects of our society, making the mankind increasingly dependent on the reliable and secure operations of the network and its services. This is a ~~heartbreaking~~scary situation, since ~~software~~ adequate quality ~~and,~~ reliability, and ~~adequate security means~~robustness against failures and hacking, of our networks and information systems are not yet in place.

9. **Do you see any technological trends?**
   The internet is mostly based on a fiber-optical transmission network, where the capacity of the transmission network is steadily being increased by refining the Dense-Wave-Division-Multiplexing technique.

   Going back to the mid-70s and the harsh struggle between the standardization community and the DARPA community, the two communication directions – virtual lines and datagrams – both had their advantageous and disadvantageous. DARPA at that time, was strongly advocating against virtual lines. It is therefore interesting to observe the effort, in the last decade or so, to integrate the advantageous of virtual lines into the internet without compromising the datagram concept. I think her on the introduction of Multi-Protocol-Label-Switching (MPLS) and queue controls in the routers, in order to fulfill real-time and other transmission service qualities.

   The internet users is steadily being more mobile, wanting to use internet service – including voice calls – from anywhere and at any time. We will see the development of more suitable PDAs, with expanded capacity and lower power consumption, combining phone, voice conferencing, and normal internet services. Such devices will not only be used to access the internet, but will increasingly be used for mobile-to-mobile communications.

   Computing elements will increasingly be embedded in things like airplanes, cars, home appliances, in farming, in the industry, in the medical world, in other words be part of the personal, commercial, and public domains. That means we will be more and more dependent on the reliable functioning of such electronic elements containing more or less ~~complex~~reliable software. We are not that far yet, and will see an increased focus on methods and tools for the development of robust and reliable software.